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[54] ACTINIC RADIATION EMISSIVE PATTERN DEFINING MASKS FOR FINE LINE LITHOGRAPHY AND LITHOGRAPHY UTILIZING SUCH MASKS

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[51] Int. Cl.[2] G21K 5/04

[52] U.S. Cl. .... 250/505; 250/492 A

[58] Field of Search .... 250/492 A, 505

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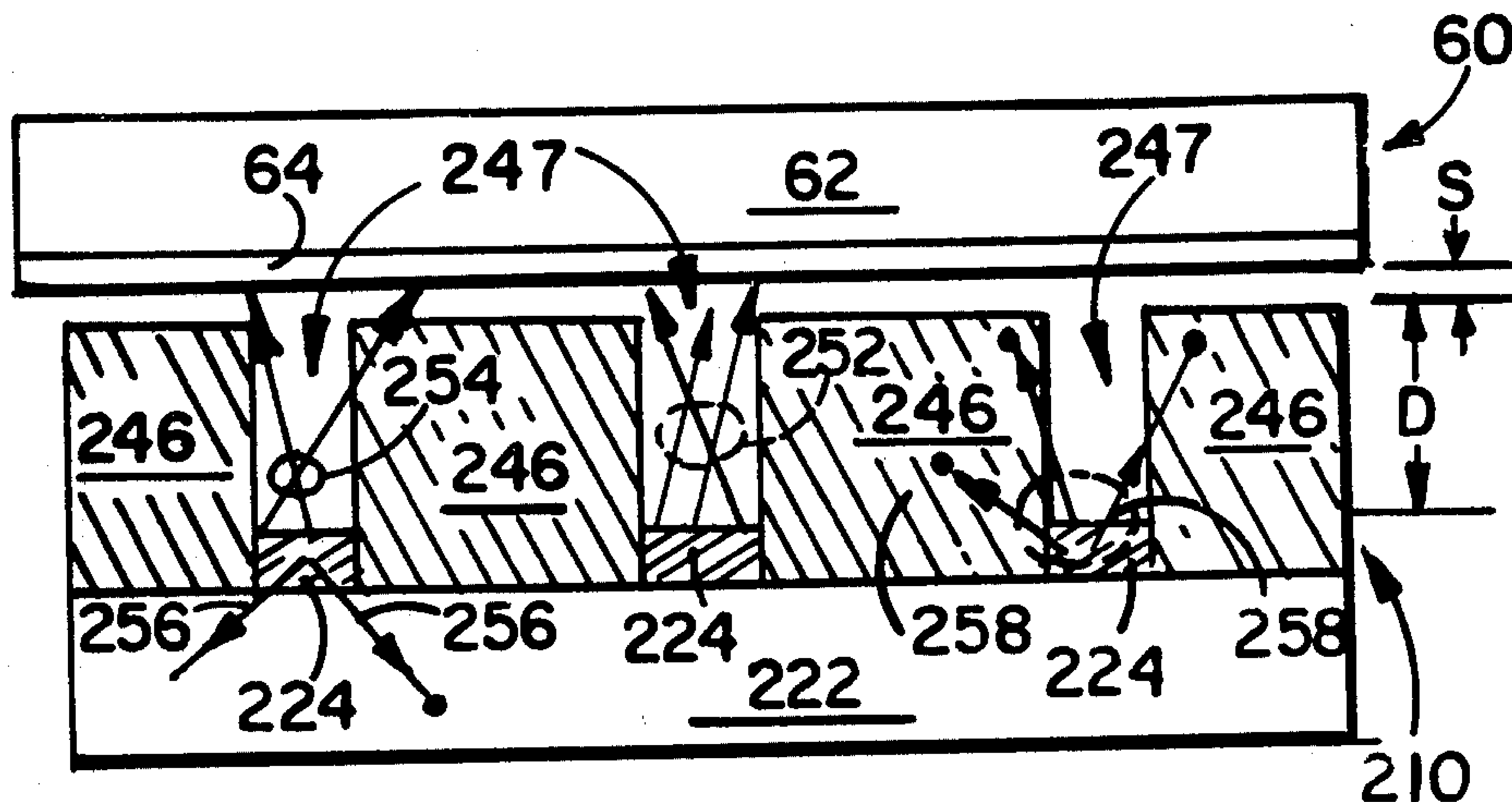
[57] ABSTRACT

An actinic radiation emissive mask for a high resolution lithography emits actinic radiation which originates within the mask. The mask patterns the actinic radiation to expose resist in accordance with a desired pattern. The actinic radiation originating in the mask may be produced by radioactivity, stimulated emission or combinations thereof.

10 Claims, 6 Drawing Figures



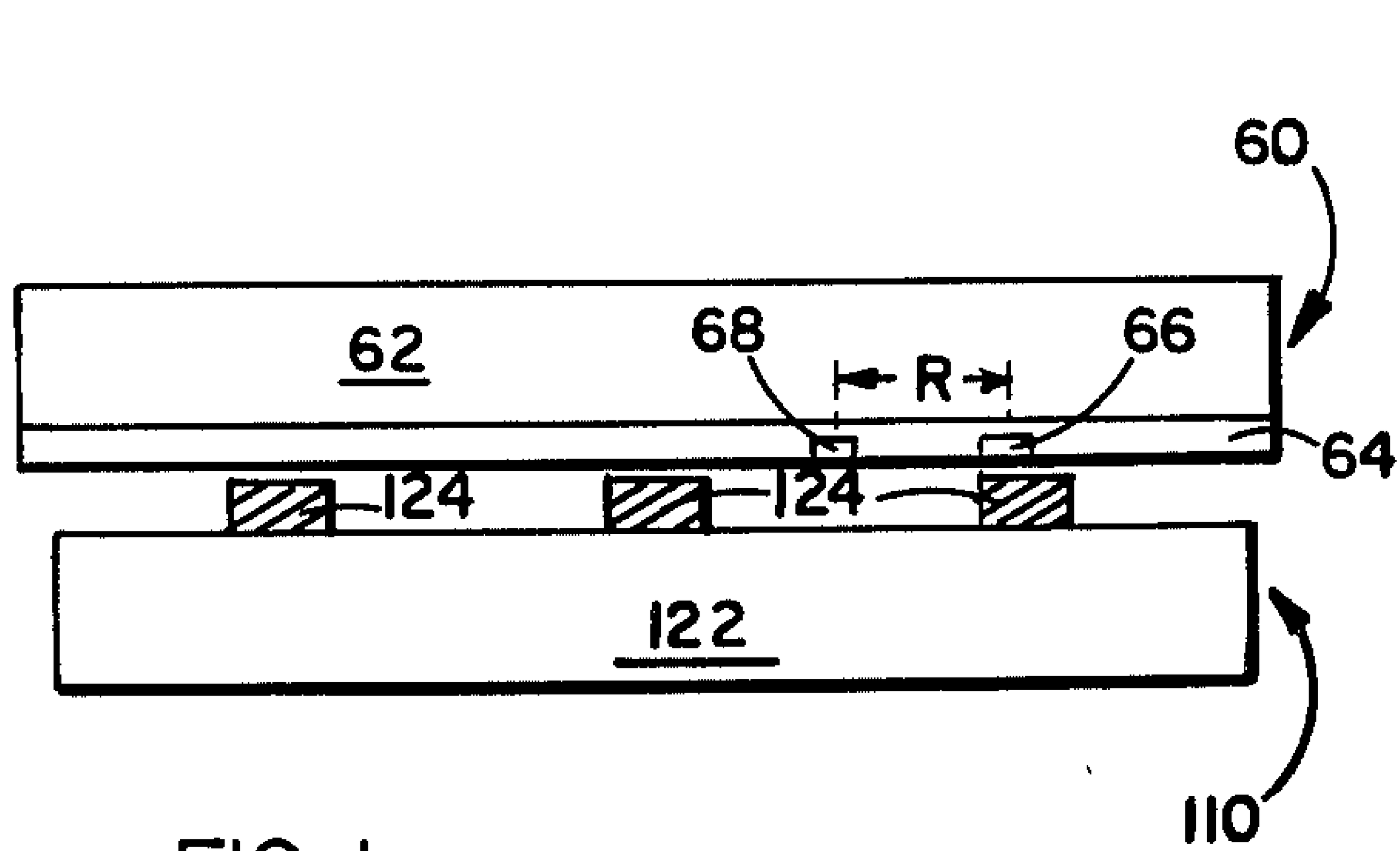


FIG. 1

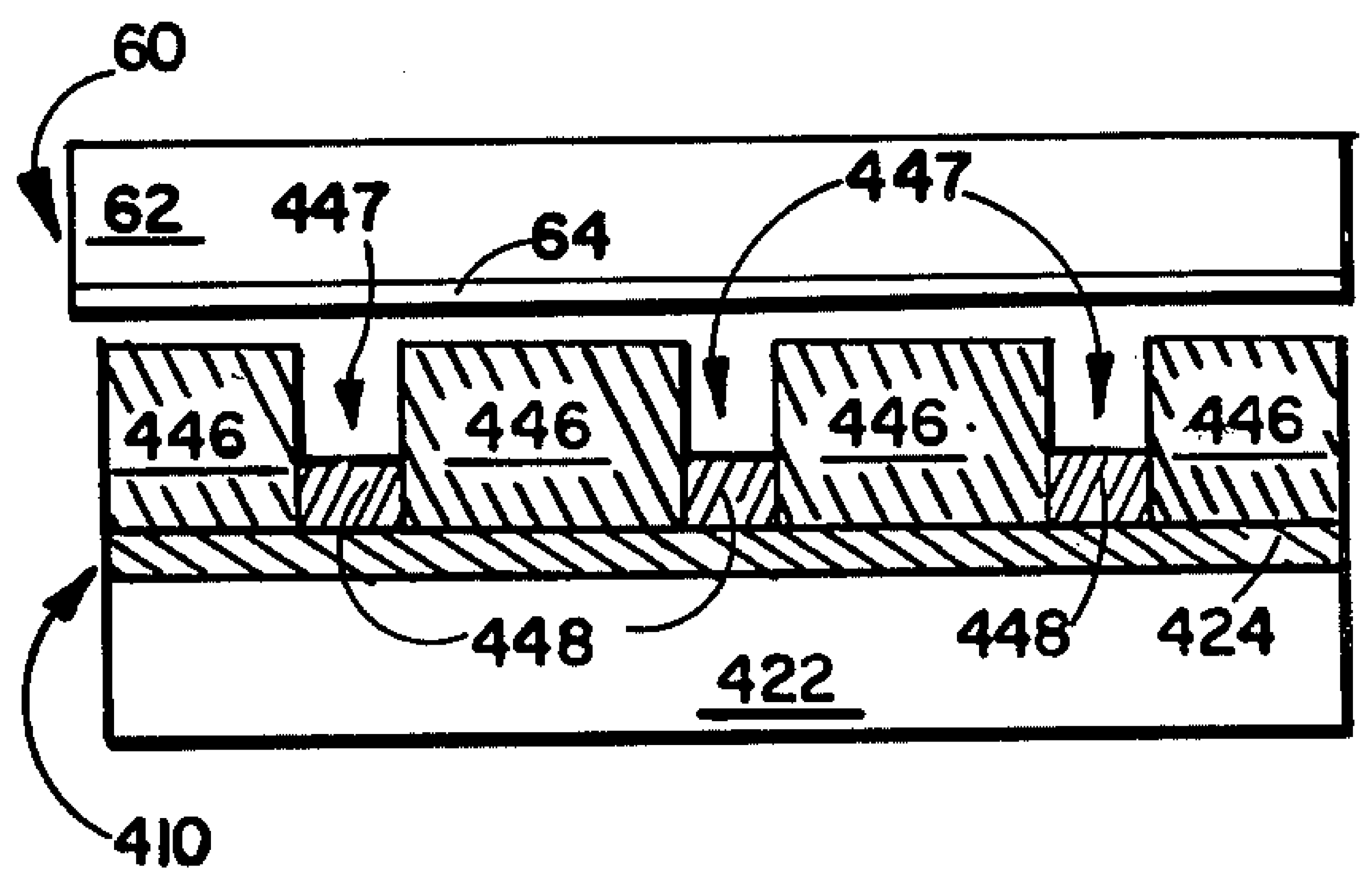


FIG. 4

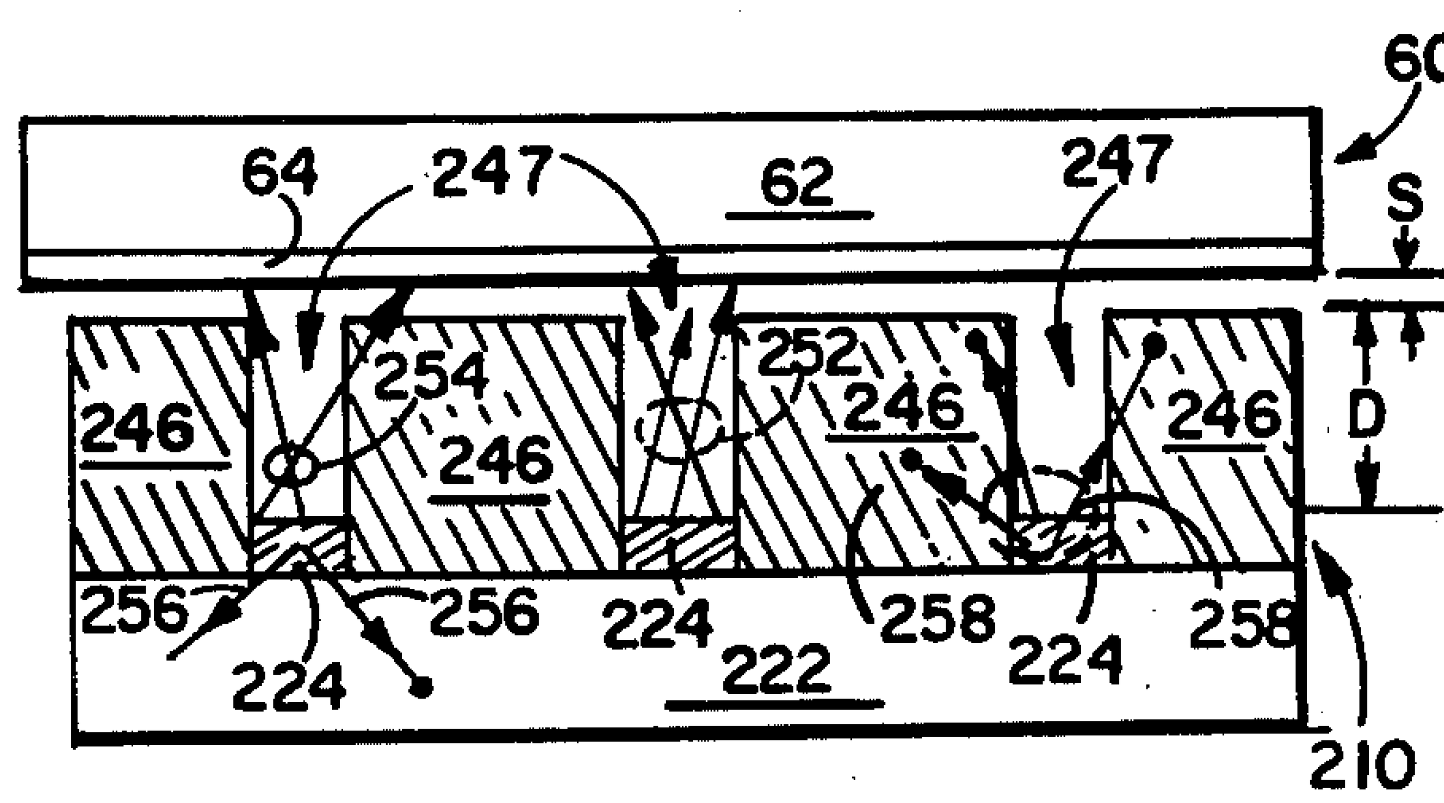


FIG. 2

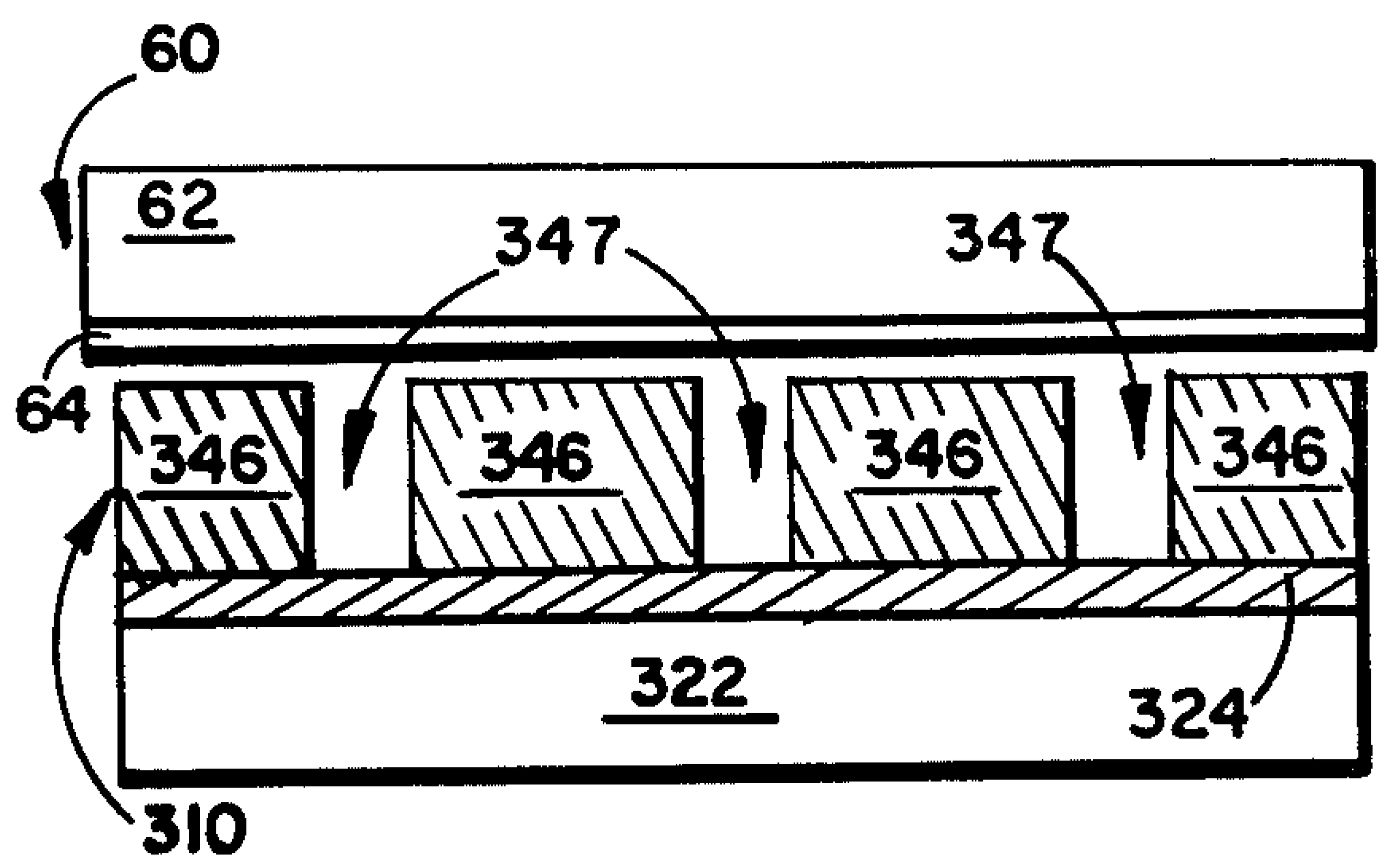


FIG. 3

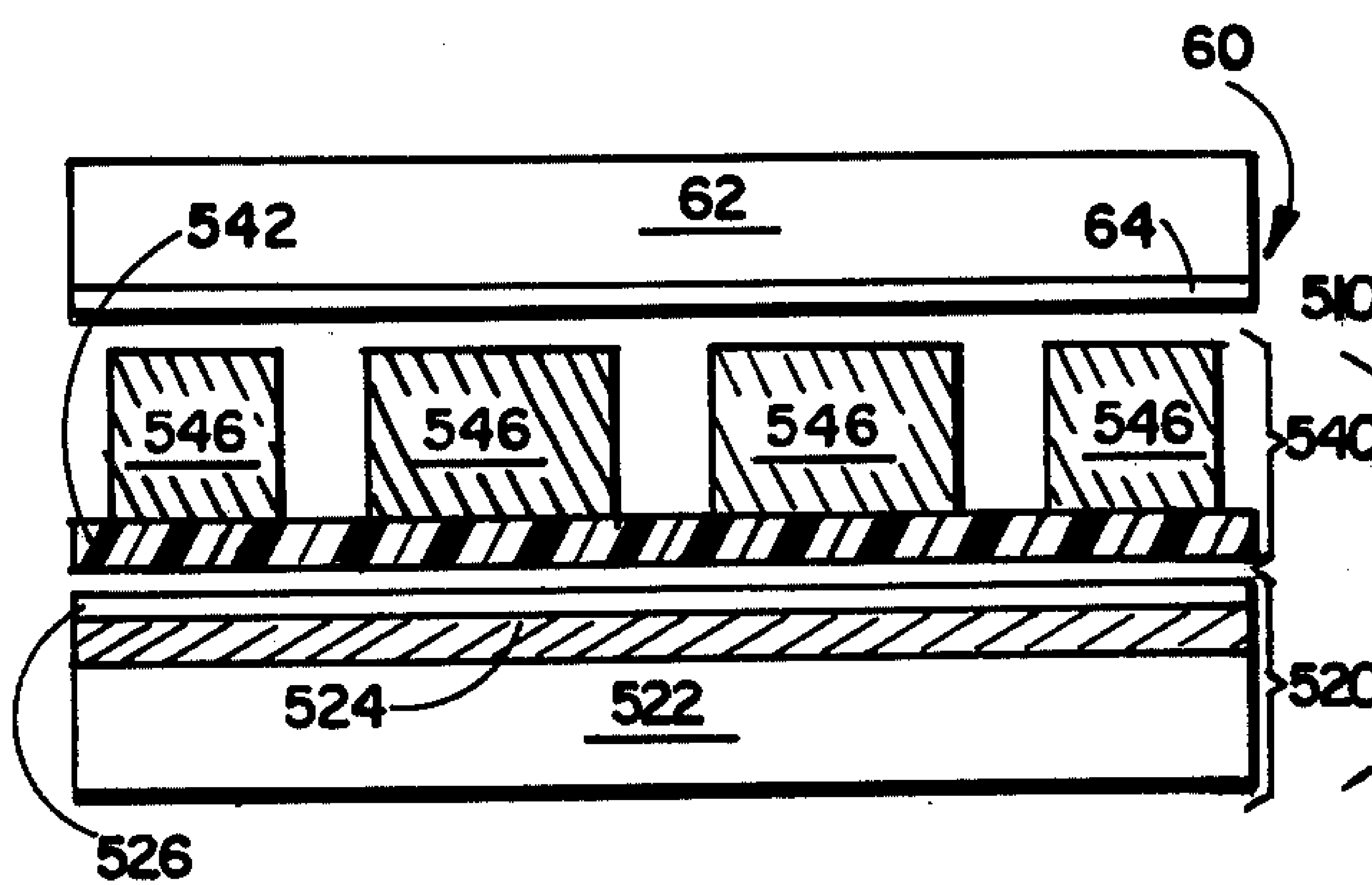


FIG.5

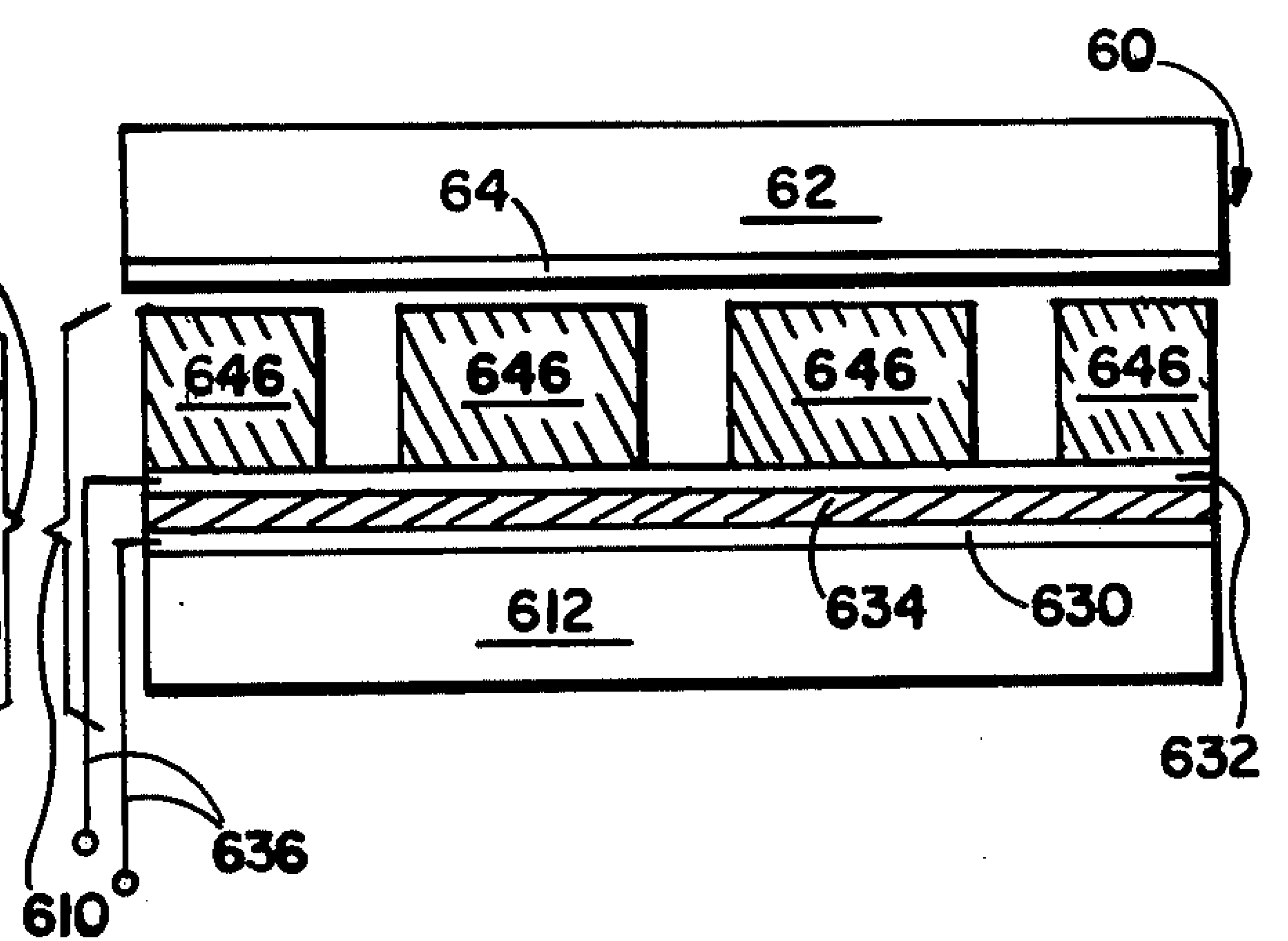


FIG.6

ACTINIC RADIATION EMISSIVE PATTERN DEFINING MASKS FOR FINE LINE LITHOGRAPHY AND LITHOGRAPHY UTILIZING SUCH MASKS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to the field of lithography for microelectronics and more particularly to high resolution lithography for use in forming dense, small, accurately dimensioned features.

2. Prior Art

Microelectronic lithography utilizing photoresists which are sensitive to visible or ultraviolet light have been in use for a number of years. These photoresists and associated exposure techniques have been a mainstay of the microelectronic arts and have been utilized for the production of countless microelectronic devices. However, as the state of the art in microelectronics has progressed, devices requiring smaller and smaller dimensions have been developed. These increasingly smaller devices have required constantly improving lithographic resolution in order to achieve satisfactory pattern definition and device yields. With currently available visible and ultraviolet light dependent exposure techniques, the minimum linear dimension of a feature of a microelectronic structure which can be accurately replicated is about 1 micron. Greater accuracy is not obtainable utilizing visible and ultraviolet actinic radiation because this actinic radiation has a sufficiently long wavelength that diffraction limits the achievable accuracy and resolution.

The adverse effects produced by diffraction can be minimized by utilization of conformable contact masks with visible and ultraviolet exposing radiation. However, contact of the mask with a microelectronic structure during manufacturing tends to introduce defects in the finished device by abrasion and contamination. Further, the resolution utilizing this technique is limited by the presence of dust particles which themselves act as individual masks and produce local separations between the mask and the substrate thereby degrading resolution.

In order to improve lithographic resolution over that obtained with ultraviolet and visible light systems, exposure techniques utilizing electron beams have been developed. Such systems provide excellent resolution but are not efficient large scale production techniques because of the high cost of exposure equipment and because present system require that the electron beam essentially draw the desired exposure pattern on the resist layer. The time required for the exposure of a pattern on an individual resist coating could be substantially reduced if electron projection lithography could be utilized. However, to date election projection lithgraphy has not been successful, inter alia, because of distortion problems.

In another attempt to improve on visible and ultraviolet light systems, X-ray lithography has been developed. This technique provides for exposure of entire wafers simultaneously. Unfortunately, special equipment is required because of the difficulty of generating well collimated X-rays of high intensity, and this complicates the overall system. Further, improved alignment techniques are needed in order to take full advantage of the benefits which may be provided by X-ray exposure.

Also as discussed in detail in an article entitled "Replication of 0.1μ Geometries with X-ray Lithography" by Feder et al., Journal of Vacuum Science Technology, Vol. 12, No. 6, November/December 1975, pages 1332–1335, secondary electron generation upon absorption of X-rays inherently limits the resolution obtainable with X-ray lithography. The degree to which secondary electron emission limits the resolution of X-ray lithography depends on the range of the secondary electrons in the photoresist. To minimize the resolution problems of X-ray lithography, Feder et al recommend the use of carbon Kα low energy X-rays which generate secondary electrons having a minimum range in the resist.

SUMMARY OF THE INVENTION

The problems of prior art lithographic systems are overcome by the present invention through use of actinic radiation emissive masks for the exposure of pattern defining resists. In a projection lithography embodiment the present invention avoids diffraction problems through utilization of actinic radiation having effective wavelengths much smaller than 1 ym. In a contact transfer embodiment of the invention, the need for projection exposure of the resist can be eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** through **6** are each cross-sectional illustrations of various embodiments of radiation emissive for radiation sensitive resist exposure masks in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

There are numerous embodiments of actinic radiation emissive masks in accordance with the present invention. These embodiments can be grouped for discussion purposes in accordance with the manner in which the actinic radiation is patterned and in accordance with the manner in which the actinic radiation originates.

In order to simplify the explanations of the various mask configurations, the following terminology will be utilized. A patterned layer in its most general sense is one comprised of at least two different types of areas which have differing characteristics. For simplicity in discussing the patterning of the mask, the patterned areas will be discussed in terms of "exposing areas" and "non-exposing areas." An "exposing area" is defined as an area of the mask which is intended to expose that portion of a photoresist layer which is in alignment therewith and a "non-exposing area" is defined as an area of the mask which is intended to prevent exposure of that portion of a resist layer which is in alignment therewith. Actinic radiation emissive material is defined as material within which the emitted actinic radiation originates, as opposed to a material which merely absorbs and/or transmits the radiation.

For clarity of discussion and reference, masks in accordance with the invention will be classified as class I or class II masks in accordance with the manner in which patterning is achieved. A mask is classified as a class I mask where patterning of the mask is achieved substantially entirely by patterning the radiation emissive material so that the radiation emissive material is present only in exposing areas of the mask. Class I masks depend on the inherent variation of radiation intensity with distance from the source which is charac-

teristic of an uncollimated source of radiation in order to produce a patterned exposure of a resist layer.

A mask is classified as a Class II mask where patterning of the mask is achieved by providing a patterned actinic radiation absorbing material between the radiation emissive material and the resist layer. The absorbing material is patterned to allow exposing quantities of actinic radiation to pass through exposing portions of the absorber and to prevent exposing quantities of the actinic radiation from passing through the non-exposing areas of the absorbing material. In a Class II embodiment, the actinic radiation emissive material may be disposed on a mask substrate either in a uniform manner both in exposing and non-exposing areas of the mask or in a patterned manner in which the emissive material is present only in the exposing areas of the mask. In either event, an actinic radiation absorber is disposed in the non-exposing areas of the mask to absorb enough actinic radiation within the non-exposing areas of the mask to render them non-exposing. Thus, the radiation absorber of this class of embodiments is patterned either as to thickness or absorption coefficient so that all but a non-exposing quantity of the emitted radiation is absorbed in the non-exposing portions of the mask, but exposing quantities of the emitted radiation pass through the exposing portions of the absorber layer to expose a resist layer brought into alignment therewith.

The actinic radiation emitting material of the mask will be classified as type I or type II in accordance with the manner in which the actinic radiation originates. An actinic radiation emitting material which spontaneously emits radiation will be classified as a type I emitting material. An actinic radiation emitting material which must be externally stimulated in order to generate exposing quantities of the emitted actinic radiation will be classified as a type II emitting material. The external stimulation required to stimulate a type II material depends on the particular type II material. The stimulation may be by radiation having characteristics which differ from those of the emitted actinic radiation, or the stimulation may be supplied in the form of electric current, electric voltage, an electromagnetic field, a chemical reaction, heat or other appropriate forms.

A class I mask in accordance with the invention is illustrated generally at **110** in FIG. **1**. Mask **110** comprises a substrate **122** which is dimensionally stable under the conditions of use and has a patterned layer of actinic radiation emissive material **124** disposed thereon. Radiation emissive material **124** is patterned to be present in exposing areas of the mask and absent in non-exposing areas of the mask. If desired, a thin protective actinic radiation transmissive film may be disposed over emissive material **124** in order to prevent material **124** from being rubbed off of or smeared along the surface of substrate **122**. Mask **110** is illustrated in alignment with a wafer shown generally at **60** which is to be exposed. Wafer **60** comprises a wafer substrate **62** having a radiation-sensitive resist layer **64** disposed on a substrate surface which is to be patterned. To expose resist layer **64**, the actinic radiation emissive material **124** of mask **110** is disposed in contact with or closely adjacent to the resist layer **64**. Radiation emissive material **124** is preferably one which emits actinic radiation having a range in the resist which is substantially equal to the thickness of the resist layer. This will maximize the resolution obtained in exposing the resist. The quantity of radiation which impinges on the resist per unit area of the resist varies with the distance of the unit area of resist from the source of the radiation. The quantity of radiation per unit area has its greatest rate of variation as a function of distance from the source in the vicinity of the source. Therefore, it is preferable to use mask **110** of FIG. **1** for contact exposure of or spaced from the resist by a distance which is small compared with the width of non-exposing areas of the mask. In this way the variation of intensity with distance can be utilized to produce selective exposure of the resist in the immediate vicinity of the radiation emissive material in preference to the exposure of the resist which is spaced further from the emissive material. As is illustrated in FIG. **1**, unit area **66** of resist **64** which is closest to the emissive material **124** will experience a substantially greater radiation dose per unit time than will the unit area **68** which is displaced from the emissive material by a distance R. Region **66** will be exposed to a radiation which is larger by a factor which is a function of R^2 than that dose to which the region **68** will be exposed. Consequently, with proper control of the exposure time, the portion of resist **64** which is in the immediate vicinity of the emissive material **124** may be fully exposed to its full depth while portions of the resist which are further from the emissive material **124** are left substantially unexposed. At the resist surface adjacent the mask an area of the resist which is exposed by the mask will have a width which is typically at least the width of the exposing emissive material segment plus twice the depth of the resist. The demarcation line between exposed and unexposed resist depends also on the characteristics of the developer utilized and the development time, as is well known in the art. At the interface between the photoresist **64** and the surface of substrate **62** an area of the resist which is exposed by the mask will typically have a width which is less than the width of the exposed area at the surface of the photoresist adjacent the mask.

Class II masks in accordance with the invention increase the density of the pattern features which may be accurately reproduced the density features which can be accurately reproduced by class I masks. A first basic class II mask is illustrated generally at **210** in FIG. **2**. Class II mask **210** comprises a substrate **222** similar to substrate **122** of class I mask **110** and patterned deposits **224** of actinic radiation emissive material similar to the patterned deposits **124** of mask **110**. In addition, mask **210** includes a patterned actinic radiation absorbing material **246** which absorbs actinic radiation which enters material **246**, thereby rendering mask **210** a class II mask in accordance with the definition given previously. Openings **247** in the patterned absorbing material **246** are aligned with the patterned deposits **224** of actinic radiation emissive material and comprise exposing areas of mask **210**. In the specific embodiment illustrated in FIG. **2**, where the openings **247** in absorbing material **246** are the same width as and aligned with the deposits of radiation emissive material **224**, the exposing areas of the mask are restricted to having substantially the same width as the corresponding portions of emissive material **224**. The areas where absorbing material **246** is present comprise non-exposing areas of mask **210**. By absorption of unwanted radiation, the radiation absorbing material **246** collimates the emitted radiation to restrict exposing intensities of the emitted radiation to the exposing areas **247** of the mask. The manner in which absorber **246** collimates the emitted radiation is illustrated by representative sets of rays **252**, **254**, **256** and **258**. Rays **252** reach resist **64** without encountering

absorber **246**. Consequently, they interact with the resist layer **64** in an exposing manner. Rays **254** pass through a small portion of the absorbing material **246** with the result that the probability of their being absorbed by the absorbing material **246** is small. Consequently, they may interact with the resist layer **64** in an exposing manner. If the nature of the emitted radiation is such that passing through absorber **246** in the manner of rays **254** reduces the energy or intensity of the emitted radiation, then some of the rays **254** will be able to interact only with the surface portion of resist layer **64**. Rays **256** are emitted in directions away from resist layer **64** with the result that they are incapable of experiencing exposing interactions with the resist **64**. Rays **258** are emitted in directions which would result in their encountering the resist layer **64** in the absence of absorber **246**. However, they are emitted in directions which carry them through substantial thicknesses of absorber **246**. As a result, there is a very small probability of any of these emitted rays passing through all of the absorber between their point of emission and the resist layer to experience an exposing interaction with the resist. As a result of the absorption of rays which pass through a significant portion of the absorbers **246**, the intensity of the emitted radiation reaching the resist is much greater within the exposing openings **247** than it is in the non-exposing areas. Consequently, by proper control of the period of time for which the resist is exposed to the actinic radiation, exposure of the resist can be limited so that only those areas which are in alignment with exposing areas of the mask will develop as exposed areas when the resist layer is developed in an appropriately controlled manner.

The collimated nature of the radiation emitted by a class II mask improves the resolution obtained with a class II mask over that obtained with a class I mask so long as the separation S between mask **210** and wafer **60** is small compared to the distance D by which the upper surface of radiation emissive material **224** is set below the upper surface of absorbing material **246**, provided the wavelength λ of the actinic radiation is much less than the dimensions of the non-exposing areas in order that the laws of geometric optics prevail. The greatest resolution will be obtained where $D >> S$. The limit for this condition is having the upper surface of absorber **246** in contact with resist layer **64** of wafer **60**. However, since such contact can create significant problems of photoresist and/or absorber scratching, a slight separation between mask **210** and wafer **60** is preferred.

The improved resolution obtained with a class II mask over that obtained with a class I mask is achieved at the expense of the use of a radiation emissive material which emits a greater quantity of actinic radiation or the use of increased exposure times. For a given intensity of radiation emission by the radiation emissive material x**24** ($x = 1$ for the class I mask **110** of FIG. **1** and $x = 2$ for the class II mask **210** of FIG. **2**) the improved resolution obtained with a class II mask as compared to a class I mask necessitates an increase in the exposure time required to properly expose a given resist layer. This is because of the variation in radiation dose per unit area per unit time with distance from the source. This variation was discussed in connection with the resolution obtained with the class I mask of FIG. **1**. This variation also directly affects the exposure time required with a class II mask even though the class II mask emits collimated radiation because the collimation of the radiation is obtained not through focusing of emitted radiation but rather through the absorption of emitted radiation which is not within the desired column. For a given intensity of emitted radiation, the exposure time required with a class II mask can be minimized by utilizing an absorber **246** which has a high absorption coefficient and making absorber **246** only as thick as is necessary to prevent exposure of the resist in the non-exposing regions of the mask and by making the distance S small enough that the ratio D/S for the resulting mask wafer alignment during exposure is sufficient to provide the desired resolution in the reproduction of the mask pattern. Since the exposure time required is inversely proportional to the intensity of the emitted radiation, the exposure time required with either a class I or a class II mask can be decreased by increasing the intensity of radiation emission by material **124** or **224**, provided this increase is obtained without changing the energy distribution of the emitted radiation, since such a change would effect the range of the emitted radiation and thus its ability to expose the resist and its ability to expose the resist and its ability to penetrate an absorbing layer. Both class I and class II masks may be utilized in mask exposure fixtures which include a shutter to prevent exposure of the resist during mask alignment.

A second basic class II mask is illustrated generally at **310** in FIG. **3**. The mask **310** is substantially identical to the mask **210**, with the exception that the radiation emissive material **324** of mask **310** forms a continuous layer rather than being patterned as is the radiation emissive material **224** of mask **210**. Consequently, the construction of mask **310** is not discussed in detail inasmuch as the relationship between the corresponding portions of the mask will be readily apparent. The exposure produced by the mask **310** will be substantially identical to that used by the mask **210**. The basic difference between the two masks is that the mask **210** requires patterning of the radiation emissive material **224** and the absorbing material **246** whereas the mask **310** requires patterning only of the radiation absorbing material **346**.

It will be understood that both masks **210** and **310** may be used either for contact exposure or for projection exposure where the mask is separated from the photoresist layer **64** by a small distance S where $S << D$.

A modified class II mask is illustrated generally at **410** in FIG. **4**. Mask **410** is similar to mask **310** of FIG. **3** and includes components which correspond to each component of mask **310**. The components of mask **410** have been given reference numerals in the **400**s which correspond to the reference numerals in the **300**s which designate the corresponding elements of mask **310**. In addition to the elements which correspond to elements of mask **310**, mask **410** incorporates a patterned radiation retarding material **448** which is disposed within the openings **447** of patterned absorbing material **446**. This mask configuration is useful where the actinic radiation emissive material emits actinic radiation having a higher energy of the emitted radiation can be reduced to a more optimum value by passing it through the radiation retarding material **448** which absorbs a portion of the energy of the actinic radiation. Where the retarding material **448** and its thickness is selected in a manner which results in the actinic radiation in the exposing areas of the mask exposing the full depth of the resist, but with insignificant quantities of the actinic radiation

entering the substrate **62**, the presence of the absorber maximizes the resolution of the mask inasmuch as any radiation which enters the absorber **446** after passing through the retarder **488** can be expected to have insufficient energy to expose the full depth of the resist. Consequently, upon properly controlled development of the resist only those portions which were in alignment with the exposing portions of the mask will be developed to their full depth as having been exposed. The thickness of the retarding material **448** which is appropriate must be determined from the optimum actinic radiation energy for exposure of the resist layer **64**, the energy of the actinic radiation emitted by radiation emissive material **424** and the rate at which the retarding material **448** retards the emitted radiation. The selection of the particular radiation retarding material which is utilized for retarders **448** will depend on the nature of the radiation emitted by radiation emissive material **424**, the degree of retardation desired and the thickness of the retarding material which is permissible in view of the mask dimensions. Where appropriate, retarding material **448** may be the same material as is utilized for absorbers **446** with the result that the absorbers **446** together with the retarders **448** form a substantially continuous coating of a single material the depth of which varies in accordance with whether that portion of the coating is within an exposing area of the mask or a non-exposing area of the mask.

The use of retarding material is also appropriate in masks of the configuration of mask **210** of FIG. **2**, when the energy of the emitted radiation makes a reduction in its energy desirable. Mask **410**, like masks **210** and **310** may be utilized either for contact exposure of the resist layer **64** or for proximity exposure of the mask where the mask is spaced slightly from the resist in order to prevent detrimental effects which might result from contact between resist layers **64** and absorber **446**. Although not preferred, it is also possible to utilize the mask as a projection mask where the separation S between the mask and the resist layer is large. Such use is not preferred because of the substantial thickness of absorbers **446** required to yield good collimation of the emitted radiation when S is large.

A further modification of class II masks in accordance with the invention is illustrated generally at **510** in FIG. **5**. Mask **510** is divided into two separate portions: an actinic radiation emissive structure **520** and a patterned actinic radiation absorbing structure **540**. Emissive portion **520** comprises a substrate **522** and a uniform actinic radiation emissive layer **524** which are similar to the substrate and emissive layer, respectively, of other class II masks. In addition, emissive portion **520** may also include an optional protective layer **526** over emissive layer **524**. The protective layer **526** should be substantially transmissive of the actinic radiation emitted by layer **524** and is intended to provide mechanical and/or environmental protection for the layer **524**. Consequently, the layer **526** need not be included when such protection is not necessary. The patterned actinic radiation absorbing structure **540** of the mask comprises a patterned absorbing material **546** which is similar to the absorbing layers of the other class II masks and which is patterned in accordance with the pattern which it is desired to expose the photoresist layer **64**. Structure **540** also must include a substrate portion **542** which is dimensionally stable in use if absorbing material **546** is not self supporting. Substrate **542** must be sufficiently transmissive of the actinic radiation emitted by layer **524** that exposing doses of the radiation are available in the exposing portions of the absorbing structure **540**. Absorbing structure **540** is removable from and reuseable with emitting structure **520**. Other absorbing structures having differing patterning may also be utilized with emitting structure **520**, thereby making **510** an alterable mask. In this way the number of emitting structures **520** which must be available in a production line may be substantially reduced from the number which would otherwise be required. The alterable mask **510** is most useful for use with patterning structures **540** which are infrequently utilized or are utilized for small production runs which do not justify the expense of a dedicated emissive layer. The masks **510** will also be useful in those situations where the separation S between the mask and the photoresist layer needs to be small enough that it is impractical to utilize a shutter to control exposure time and the exposure time is short enough that alignment of the absorbing structure **540** with the wafer **60** must be accomplished in the absence of exposing actinic radiation and the emissive layer **524** is a type I material which spontaneously emits actinic radiation. In these circumstances, the absorbing structure **540** may be aligned with the wafer **60** while the emitting structure **520** is not present and the emitting structure **520** placed on absorbing structure **540** after alignment is achieved. If emissive layer **524** is a type II emissive material which only emits actinic radiation upon external stimulation then emitting structure **520** and the absorbing structure **540** may be combined prior to aligning the mask **510** with the wafer **60** even where short exposure times are utilized because the external stimulation which is required to cause the type II material to emit actinic radiation can be withheld until proper alignment is achieved.

Resists for use with this invention may be selected from electron sensitive and photon sensitive resists in accordance with the selected actinic radiation and may include polymethyl methacrylate, poly (butane - 1 sulfone), epoxidized polybutadiene, poly glycidyl methacrylate-ethyl acrylate, poly methacrylamide, vinyl ether-maleic anhydride copolymer and so on.

The actinic radiation transmissive materials are composed on thin films or layers of low atomic number elements, while materials composed of high atomic number elements are actinic radiation absorbers and retarders.

Type I emitting materials which spontaneously emit the actinic radiation will generally be radioactive. In order to simplify the presentation thereof, representative types of radiation which may be provided by type I emissive material are presented along with representative source materials in Table 1.

TABLE 1

Actinic Radiation	representative source materials
β	H^3, Kr^{85}, Pr^{147}, Ru^{106}, Ni^{63}, Re^{187} Am^{241}
α	Ho^{153}, Er^{154}, Po^{208}, Po^{209}, Po^{210}
γ	I^{129}, Hg^{197}
Photons by Electron Capture	Ho^{163}, Cd^{109}, Ni^{59}, Fe^{55}, Rh^{102}
Electrons and by Isomeric Transition	Ta^{181}, Rh^{103}, Nb^{93}

Type II emitting materials which require external stimulation may be stimulated in a number of different ways in accordance with the characteristics of the emitting material. A number of representative type II source materials are presented in Table 2 along with the type of

radiation emitted thereby and the form in which stimulation is provided.

TABLE 2

Actinic Radiation	Emitting Material	Stimulated by
Secondary Electrons	Heavy Metals	X-Rays
X-rays	β-emitter	β-rays
X-rays	Elemental Target	Electron Bombardment
Photons	Light Emitting Diode	Electric Current
UV-soft X-rays	Plasma	Laser

Neither Table 1 nor Table 2 is intended to be limiting as to the emitting materials which may be utilized in the mask in accordance with this invention, but rather are intended to be illustrative of some basic type I and type II emissive materials. It will be noted that radiation stimulated type II materials may be ones which emit the actinic radiation as an inherent by-product of absorption of the incident radiation or may be ones in which the incident radiation is absorbed and subsequently re-emitted as actinic radiation in a manner similar to that utilized in optically pumped lasers. Other emitting layers may themselves be microelectronic devices which are stimulated by externally supplied voltage or current as in the use of a light emitting diode or solid state lasing structure.

Radiation conversion makes in accordance with the invention overcome the inherent resolution problem of x-ray lithography by intentionally generating long range secondary electrons having a penetration range sufficient to expose the entire depth of the photoresist layer and by positioning the patterning layer of the mask to selectively absorb the secondary electrons emitted by the radiation conversion material rather than positioning the patterning layer of the mask to absorb the incident X-rays as is done in the prior art. In this way, an incident X-ray flood is converted to individual collimated beams of secondary electrons which are restricted to those areas where it is desired to expose the photoresist. Thus, radiation conversion masks in accordance with the invention achieve the results toward which flooding-type electron lithography has been striving, while avoiding projection electron lithography's distortion and problems of obtaining uniform exposure of the resist material beneath the transmissive portions of the mask while simultaneously achieving total absorption of the electrons in the non-transmissive portions of the mask. It will be noted that where X-rays are utilized to generate actinic secondary electrons, relatively hard or high energy X-rays which generate secondary electrons having a range greater than or equal to the depth of the resist, may be utilized to obtain high resolution exposure, contrary to the teachings of the prior art.

When the radiation conversion material and the secondary electron-absorbing material are both conductive, the mask may be connected to a predetermined potential such as ground voltage in order to prevent the emission of secondary electrons from causing the mask to accumulate a charge which could have detrimental effects on the mask and/or the device on which the resist layer is disposed.

A further embodiment of a class II mask incorporating a type II electrically stimulated emissive material is illustrated generally at **610** in FIG. **6**. Mask **610** comprises a substrate **612**, a conductive layer **630** disposed thereon, electrically excitable radiation emissive layer **634** disposed on layer **630**, a second conductive layer **632** disposed on layer **634** and a radiation absorbing layer **646** disposed on layer **632**. Emissive layer **634** may comprise a solid state laser or light emitting diode which emits actinic radiation capable of exposing the photoresist layer **64** of wafer **60**. The details of the internal construction of layer **634** and the nature and configuration of conductive layers **630** and **632** will depend on the particular implementation utilized to convert input electric power to emitted radiation. However, any material (including layer **632**) which is disposed between the emissive material **634** and the resist **64** in exposing areas of the mask must be sufficiently transmissive of the emitted actinic radiation to allow exposing intensities of the actinic radiation to reach the resist. It will be understood that the ultimate resolution producible with mask **610** will depend on the wavelength of the emitted radiation and the separation between resist layer **64** and mask **610** since these characteristics control the extent to which diffraction will limit the resolution obtainable.

EXAMPLE

A layer of poly glycidyl methacrylate-co-ethyl acrylate resist material was disposed on a test substrate via well known spinning techniques. The resulting resist layer was prebaked in accordance with accepted procedures. A self-supporting patterned metallic absorbing structure was disposed on the resist layer. A radiation emissive structure including 100 microcurie A_m^{241} source of radiation was placed on the absorbing structure for a period of 1000 hours. Following normal development of the resist, an overexposed resist pattern remained on the substrate, the pattern was a negative of the absorbing structure as was expected.

A new class of masks for patterned exposure of resists for microelectronics has been illustrated and described. Those skilled in the art will be able to vary the details of the illustrative preferred embodiments, however, since these embodiments are illustrative, rather than limitive, the protection afforded this invention is defined by the appended claims.

What is claimed is:

1. A mask for exposing radiation sensitive resist in a non-uniform, patterned manner comprising:

substrate means;

actinic radiation emissive means supported by said substrate means for emitting actinic radiation; and

patterning means disposed between said actinic radiation emissive means and the location in which a resist layer to be exposed would be located for restricting the emitted actinic radiation to exposing resist in a non-uniform manner determined by the pattern of said patterning means.

2. The mask recited in claim **1** where said actinic radiation emissive means comprises actinic radiation emissive material disposed on said substrate means in a pattern corresponding to the desired resist exposure pattern.

3. The mask recited in claim **1** wherein:

said actinic radiation emissive means is disposed on said substrate means at least in those areas where exposure is desired; and

said patterning means comprises actinic radiation absorbing means disposed to absorb actinic radiation which would expose portions of a resist layer which it is desired to leave unexposed.

4. The mask recited in claim **3** wherein said actinic radiation absorbing means is patterned to be less absorb-

ing in areas where exposure is desired than it is in areas where non-exposure is desired.

5. The mask recited in claim 4 wherein said radiation absorbing means is thinner in areas where exposure is desired than in areas where non-exposure is desired.

6. The mask recited in claim 1 wherein said actinic radiation emissive means comprises a material which spontaneously emits actinic radiation without external stimulation.

7. The mask recited in claim 1 wherein said actinic radiation emissive means comprises radiation emissive means which emit actinic radiation only in response to external stimulation.

8. A method of exposing a resist layer in a patterned manner comprising:

disposing in proximity to and in proper alignment with said layer a patterned mask which emits patterned actinic radiation in a self-limited exposing pattern without need for externally supplied focusing fields; and

removing said mask after a period of time which provides proper exposure of said resist in the pattern of said mask.

9. The method recited in claim 8 wherein said mask only emits actinic radiation in response to external stimulation and said method further comprises externally stimulating said mask while it is in proper alignment with said layer and for a time which provides proper exposure of the resist.

10. A mask for exposing radiation sensitive resist in a non-uniform, patterned manner comprising:

substrate means;

patterned actinic radiation emissive means supported by said substrate means for exposing resist in the pattern of said actinic radiation emissive means;

said mask adapted to be placed in sufficiently close proximity to the resist to be exposed that chemically distinguishable degrees of exposure result from the $1/R^2$ dependency of the actinic radiation intensity, wherein R is the distance from the emissive material to the resist material.

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